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ABSTRACT

To demonstrate that properly designed laboratory instruction does provide affective and higher order learning benefits, an experiment was carried out in two replications. The subjects were 80 students enrolled in General Microbiology at Wallace Community College, Alabama. Students were randomly assigned to experimental and control groups. The experimental group was randomly assigned a culture of bacterium to be identified. Using references and a list containing their unknowns, they were told to work independently. Instructors provided no help except supervision for safety purposes. The control group continued with step-by-step verification laboratory exercises, working in pairs with direct supervision and instruction. Following three weeks of treatment, the Watson-Glaser Critical Thinking Appraisal and then the Scientific Attitude Inventory were administered. Results indicate that the treatment of the independent laboratory investigation did not have a significantly different effect on the dependent measures of critical thinking ability and/or scientific attitude when compared to the effect of the performance of verification laboratory exercises by a control group. (PN)

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The Effects of an Independent Laboratory Investigation on the Critical Thinking Ability and Scientific Attitude of Students in a General Microbiology Class

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The Effects of an Independent Laboratory Investigation on the Critical Thinking Ability and Scientific Attitude of Students in a General Microbiology Class

In many biology courses, a large portion of time and expense are devoted to laboratory work (Bates, 1978; Edwards, 1980). However, comparatively little research has been done on the laboratory form of instruction (Kozma, Belle, & Williams, 1978). It is generally agreed that the research findings on the exact results and benefits derived from the laboratory method of instruction are not conclusive (Saunders & Dickinson, 1979; Bates, 1978).

The Commission on Undergraduate Education in Biological Science recommended that biology courses provide learning benefits that will be relevant throughout the student's life. This group suggested that this role be carried out by the investigative laboratory as it functions to demonstrate the nature of biology and demand critical thinking (Thornton, 1972).

Unfortunately, many science teaching laboratories only seem to provide training in skills or to serve an illustrative function. Furthermore, some researchers have hypothesized from research results that possibly all that is gained from student laboratory experience is technique (Kozma et al., 1978).

Laboratory assignments, such as identifying an unknown in an independent laboratory investigation, can provide affective and higher order learning benefits in addition to skills. These benefits are thought to involve changes in scientific attitude and critical thinking ability.

Azima and Henry (1980) proposed that laboratory experiences, which effect disequilibration, may facilitate the progression of the student's intellectual development. Bates (1978) noted that the inquiry-type laboratory activities appear better than lecture-demonstration or verification laboratories in promoting development marked by increased reasoning ability.

This study was undertaken in response to a challenge to demonstrate that properly designed laboratory instruction does provide something special--affective and higher order learning benefits--for students (Bates, 1978). Specific research questions were:

1. Does the treatment of an independent laboratory investigation (as compared to verification laboratory exercises), the replication of the treatment with a second group of students, or a combination of treatment and replication have a significant effect on critical thinking ability as measured by the students' scores on the Watson-Glaser Critical Thinking Appraisal?

2. Does the treatment of an independent laboratory investiagtion (as compared to verification laboratory exercises), the replication of the treatment with a second group of students, or a combination of treatment and replication have a significant effect on scientific attitude as measured by the students' scores on the Scientific Attitude Inventory?

3. Does the treatment of an independent laboratory investigation, the replication of the treatment, or a combination of treatment and replication have a significant effect on critical thinking ability and scientific attitude as measured by combined scores on the Watson-Glaser Critical Thinking Appraisal and the Scientific Attitude Inventory?

To answer these research questions, the following null hypotheses were tested. Because of the nature of this study and the multivariate techniques which were used to analyze the data, interaction hypotheses will be given first, followed by hypotheses for effects of treatment and replication.

Interaction

1. There is no significant interaction effect for treatment condition and replication on combined scores from the Watson-Glaser Critical Thinking Appraisal and the Scientific Attitude Inventory.

2. There is no significant interaction effect for treatment condition and replication on scientific attitudes as measured by the Scientific Attitude Inventory.

3. There is no significant interaction effect for treatment condition and replication on critical thinking ability as measured by the Watson-Glaser Critical Thinking Appraisal.

Treatment

4. There is no significant difference in the effect of an independent laboratory investigation (treatment) and verification laboratory exercises (control) on combined scores from the Watson-Glaser Critical Thinking Appraisal and the Scientific Attitude Inventory.

5. There is no significant difference in the scientific attitude (measured by the Scientific Attitude Inventory) of students who received the treatment of an independent laboratory investigation and the control group of students who carried out verification laboratory exercises.

6. There is no significant difference in the critical thinking ability (measured by the Watson-Glaser Critical Thinking Appraisal) of students

receiving the treatment of an independent laboratory investigation and the control group of students who carried out verification laboratory exercises.

Replication

7. There is no significant difference for the effect of replication on combined scores from the Watson-Glaser Critical Thinking Appraisal and the Scientific Attitude Inventory.

8. There is no significant difference in the scientific attitude (measured by the Scientific Attitude Inventory) of students in replication one and those in replication two.

9. There is no significant difference in the critical thinking ability (measured by the Watson-Glaser Critical Thinking Appraisal) of students in replication one and those in replication two.

Method

Subjects

A total of 80 community college students enrolled in General Microbiology at Wallace Community College were used as subjects in this investigation. Wallace Community College is a comprehensive community college in southeastern Alabama with 2,885 students enrolled fall quarter, 1984. The majority of the students who enroll in General Microbiology are majoring in health programs such as nursing, respiratory therapy, medical laboratory technology, and emergency medical technology. Most of them are white females and from within or near the Dothan, Alabama, area.

Procedure

This experiment was carried out in two replications. The two fall quarter General Microbiology classes, each with a different instructor, were

used for replication one. The two winter quarter General Microbiology classes, each with the same instructor, were used for replication two. These classes meet 7 hours each week with two 2-hour laboratory sections and three 1-hour lectures.

The first 5 weeks of the quarter, all the students used their laboratory time performing and observing step-by-step exercises (sometimes modified) from Laboratory Microbiology by Bradshaw (1979) in order to learn techniques and cognitive skills to help them in their investigative study. In each class at the beginning of the sixth week the students were randomly assigned to experimental and control groups. Each member of the experimental group was randomly assigned a culture of bacterium to be identified. Most of the bacteria were included, along with others, in a list that was suggested in Laboratory Microbiology to be used for unknowns. The students had this list, and they were told that their unknowns would be taken from this list and from an addendum which they were given.

The experimental groups with unknowns were told to work independently and to be completed with the identification of their unknowns by the end of 3 weeks. They were allowed to use the laboratory manual, notes, and any other references with Bergey's Manual of Determinative Bacteriology (Buchanan & Gibbons, 1974) being an essential reference. They had to choose the necessary laboratory procedures, to decide the order in which to perform these procedures, and to interpret the results. The instructor provided no help except to supervise for safety purposes.

The control goup continued with the step-by-step verification laboratory exercises. These exercises (with some modifications) were chosen

from Laboratory Microbiology (Bradshaw, 1979). The control students, working in pairs, were given exact instructions for performance, expected results, and interpretation of the exercises. Furthermore, they were told which procedures to use and the order in which to do them.

The students in the experimental group as well as those in the control group could, at the student's request and with the instructor's supervision, spend additional time in the laboratory. Members from both groups did spend additional time in the laboratory, but students working on unknowns (experimental group) were observed to spend considerably more time in the laboratory than was observed for the control group.

At the next class meeting following the 3 weeks of treatment, both control and experimental groups were given first the Watson-Glasser Critical Thinking Appraisal and then the Scientific Attitude Inventory.

Instruments

The Watson-Glaser Critical Thinking Appraisal was used to measure critical thinking ability. It is made up of five subtests: inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments (Watson & Glaser, 1980). The alpha coefficient calculated to determine this instrument's reliability for the sample being studied was .81.

The Scientific Attitude Inventory was used to measure scientific attitudes. Moore and Sutman (1970) described the development, field test, and validation of the Scientific Attitude Inventory. The Scientific Attitude Inventory assesses four categories of attitudes: positive intellectual, negative intellectual, positive emotional and

negative emotional. The alpha coefficient for subjects in this study was .76.

Analyses and Results

The relationships between two independent variables and two dependent variables were investigated. The design was a 2 x 2 multivariate analysis of variance. The first factor was treatment and consisted of two levels, independent laboratory investigation (treatment) and verification laboratory exercises (control). The second factor was replication which also consisted of two levels, replication one and replication two. The two dependent measures were critical thinking ability and scientific attitude.

All of the data were analyzed using the IBM 3033 Computer and the Statistical Package for the Social Science (SPSS). Means and standard deviations were calculated by using program breakdown available in SPSS.

The scores on the two dependent variables were used to test each of the null hypotheses utilizing the combination approach for multivariate data suggested by Hummel and Sligo (1971). This procedure, as described by Hummel and Sligo, requires that a significant F ratio must be obtained on the MANOVA in order to appropriately interpret the subsequent univariate ANOVAs. The Wilks Lambda criterion at the $p < .10$ level of significance was utilized.

The results of the MANOVA, using combined scores for the two dependent measures, are presented in Table 1. ANOVA results are given in Table 2. The means and standard deviations of the dependent variables are presented in Table 3.

Insert Tables 1, 2, and 3 about here.

The multivariate F ratio for the interaction effect was not significant (see Table 1), precluding interpretation of the univariate interaction effects. The multivariate F ratio for treatment was not significant (see Table 1). Thus, the main effects for treatment were not interpreted. The multivariate F ratio for replication was not significant (see Table 1). Therefore, the main effects of replication were not interpreted.

Discussion and Conclusions

From the results of the study one may conclude that the treatment of the independent laboratory investigation did not have a significantly different effect on the dependent measures of critical thinking ability and/or scientific attitude when compared to the effect of the performance of verification laboratory exercises by a control group. No statistically significant effect was found for replication on the dependent variables, and there was no significant interaction effect of treatment by replication. All null hypotheses were supported.

In examining the results of this study, one is disadvantaged by the fact that the emphasis placed on laboratory instruction has been based more on opinion than on empirical research findings. There is very limited research involving laboratory investigations. In the studies which have been done, generally no significant differences in critical thinking/attitudes have resulted from laboratory and non-laboratory teaching techniques (Bates, 1978).

Considering these studies, Bates (1978) noted: "Many of the 'nonsignificant differences' observed when comparing teaching methods may occur because the conflicting effects on different students average to zero" (p. 71). Even if the treatment in the present study had a significant effect on some students, it may have appeared as nonsignificant when the mean for the group of students was considered.

In order to understand better conflicting effects on different students, interpersonal variables would need to be considered. Learning style is possibly one of the influential variables. In a study of conventional laboratory activities versus research laboratory activities, Kampwirth (1972) found that the experimental group working with the research project had a lower opinion of the laboratory experience than did the control group working with the conventional laboratory activities. The junior college students in the experimental group did not favor working at the required level of independence. Since 2-year college students were involved in the present study, some in both the treatment and control groups may have preferred more direction such as that received by the control group while others in both groups might have liked the independence in the treatment condition.

Another problem to be considered is whether or not a change in critical thinking ability and/or scientific attitude can be measured by a general instrument such as the Watson-Glaser Critical Thinking Appraisal or the Scientific Attitude Inventory. In a study testing the effects of an inquiry-type laboratory experience versus a traditional verification laboratory experience on college physical science students, no significant difference was assesssed with the Watson-Glaser instrument, although a

critical thinking measure in physical science that was designed by the investigators did show the inquiry group to be superior (Bates, 1978). Likewise, the significant differences found by Kampwirth (1972) were in scores from a specific attitude measure rather than the Silance-Remners Scale measuring general attitude toward biology.

Bates (1978) agreed that the general purpose instruments, such as the Watson-Glaser, may not measure "specifically science oriented capacities" (p. 66) and warned that what is learned through science instruction cannot be assumed to be transferred to other areas of thinking. Thus, more treatment-specific instruments may be needed before differential effects of various laboratory experiences are detected.

The need for a longer-than-usual training period has also been suggested. In a study reported by Bates (1978), significant differences were noted in measured analytical abilities of elementary and junior high students who were given 3 years of training as compared to the control group. Treatment time was a limitation in the present study; however, a lengthy training time would involve factors that would be a threat to the validity of the experimental design.

Important questions therefore remain. Are differential effects of varied laboratory experiences in science more specific than general? If there are specific or general effects, are they significantly different only after extensive laboratory experiences? Will the effects be different with different types of students?

Recommendations for future research designed to help answer these questions include:

1. Replication of this study with treatment extending over a longer period of time;

2. Inclusion of student learning style as an independent variable;

3. Use of more sensitive and possibly more specific measuring devices.

An empirical base for laboratory experiences in science classes is definitely needed. Additional research as suggested would help fill the existent void.

References

Azima, K., & Henry, R. (1980). Teaching students to reason: An application of Piagetian psychology to college teaching (Papers on Learning and Teaching No. 76). East Lansing: Michigan State University, Learning and Evaluation Service. ERIC Document Reproduction Service No. ED 192674)

Bates, G. (1978). The role of the laboratory in secondary school science programs. In M. B. Rowe (Ed.), What research says to the science teacher. Washington, DC: National Science Teachers' Association.

Buchanan, R. E., & Gibbons, N. E. (Eds.) (1974). Bergey's manual of determinative bacteriology (8th ed.). Baltimore, MD: William and Wilkins.

Bradshaw, L. J. (1979). Laboratory microbiology. Philadelphia: Saunders.

Edwards, S. J. (1980). Science education in two-year colleges: Biology. Los Angeles: Center for the Study of Community Colleges and ERIC Clearinghouse for Junior Colleges.

Hummel, T., & Sligo, J. (1971). Empirical comparisons of univariate analysis of variance procedures. Psychological Bulletin, 76, 49-57.

Kampwirth, R. G. (1972). A comparison of a conventional junior college biology laboratory versus a research project laboratory. Dissertation Abstracts International, 33, 2784A. (University Microfilms No. 72-32474)

Kozma, R., Belle, L. W., & Williams, G. W. (1978). Instructional techniques in higher education. New Jersey: Educational Technology Publications.

Moore, R. W., & Sutman, F. X. (1970). The development, field test, and validation of an inventory of scientific attitudes. Journal of Research in Science Teaching, 7, 85-94.

Saunders, W. L., & Dickinson, D. H. (1979). A comparison of community college students' achievement and attitude changes in a lecture-only and lecture-laboratory approach to general education biological courses. Journal of Research in Science Teaching, 16, 459-464.

Thornton, J. W. (Ed.). (1972). The laboratory: A place to investigate. Washington, DC: American Institute of Biological Sciences.

Watson, G., & Glaser, E. M. (1980). Critical thinking appraisal manual. Chicago: Harcourt, Brace, and Jovanovich.

Table 1

MANOVA Summary Table: Treatment/Replication with Critical Thinking Ability and Scientific Attitude as Dependent Measures

Source	df	F
Interaction	2,75	.53
Treatment	2,75	.34
Replication	2,75	.47

Table 2

ANOVA Summary Table: Critical Thinking Ability and Scientific Attitude with Treatment Condition and Replication as Independent Variables

Source	df	SS	MS	F
		Critical Thinking Ability		
Main Effects	2	119.76	59.88	.81
Replication	1	70.50	70.50	.95
Treatment	1	49.26	49.26	.66
Interaction	1	60.25	60.25	.81
Explained	3	180.01	60.00	.81
Residual	76	5,640.62	74.22	
Total	79	5,820.63	73.68	
		Scientific Attitude		
Main Effects	2	8.52	4.26	.03
Replication	1	6.82	6.82	.04
Treatment	1	1.70	1.70	.01
Interaction	1	94.84	94.84	.60
Explained	3	103.37	34.46	.22
Residual	76	11,950.08	157.24	
Total	79	12,053.45	152.58	

Table 3

Means and Standard Deviations for Dependent Measures by Treatment Condition and Replication

Group		Critical Thinking Ability	Scientific Attitude
Total Group	M	54.06	117.43
	SD	8.58	12.35
Replication One	M	54.87	117.17
	SD	8.91	12.36
Replication Two	M	52.97	117.76
	SD	8.13	12.36
Treatment (Independent Lab Investigation)	M	53.32	117.56
	SD	8.40	12.87
Control (Verification Laboratory Exercises)	M	54.85	117.28
	SD	8.81	11.95
Replication One Treatment	M	54.83	116.42
	SD	8.12	12.10
Replication One Control	M	54.91	118.00
	SD	9.89	12.86
Replication Two Treatment	M	51.18	119.18
	SD	8.57	14.10
Replication Two Control	M	54.76	116.35
	SD	7.48	10.97